Summary of the Mineralogy of Stardust Tracks Investigated During the Sample Preliminary Examination Period

Compilation and editorial comments by Mike Zolensky

Track 1

Grain 1

No data yet

Grain 2

Bajt [IR spectroscopy]: One olivine peak in S1, one possible olivine peak in S2.

Rietmeijer [TEM]: (1) One
grain is pure Mg.Fe; (Mg/(Mg+Fe) (mg) = 0.7. Mg,Fe silicates with ~1 wt% CaO and ~1 wt% MnO; mg = ~0.8 to 0.9. Mg. Fe-silicate with variable, 1-4 wt% Al_2O_3; mg = ~0.7. Probably amorphous, no evidence for crystalline material. FeS +/- Ni abundant in vesicular material. No CLEAN sulfide analysis. See ternary diagram of ONE sulfide. Grain mixed with silicate-rich material (Fe compositions of the sulfides should be corrected of the Fe from the silicates).

Stefan [TOF – SIMS]: Mapping – bulk data. Few element chondritic relative to Fe (Al, Cr, Mn, Co, Cu) other enriched (C, O, Na, S, Sc, Ti).

Mikouchi [TEM – FEG SEM]: Tiny Fe sulfides scattered. Lot of aerogel. Sulfides possibly formed during impact melt.

Stroud: Sees OPX (verified by ED). Ca-Al-bearing silicate nanotubes and Ca carbonates, which all appear to be contamination.

Track 2

Grain 2

Bridges [SEM]: Aerogel mainly

Simon [TEM]: Vesiculated, with nanophase FeNi and FeNi sulfide grains in an Mg-silicate host. High TiO_2 phase.

Stefan [TOF SIMS]: Li, Mg, P, Ca, Ti, V, Cr, Mn, Ni are clearly chondritic. Na. K, Rb, B, Si, O, Cl diverse types of contamination.

Grain 4

Aleon [Presumably SEM]: Could not find particles on Si wafer

Track 3

Grain 1

Tomeoka [TEM]: Mostly aerogel. Some large grains. Relatively large grains are: (1) Al-Zr-O material (amorphous), (2) Si-O phase (crystalline), and (3) Si-Ca-Mg-Al-O material (amorphous), and (4) Ti-O phase (crystalline), roughly in the order of abundance.

Minor constituents are: (1) K-Al-Si-O phase (crystalline), (2) Ca-O phase (crystalline), and (3) Fe-O phase (crystalline). EDS analyses and SAED patterns of K-rich grain suggest that it may be related to K-feldspar. Ca rich grain might be carbonate.

Kearsley [SEM]: The grain of interest has apparently a high Ca content, and we believe that the Si may be from a thin aerogel envelope as it seems to be highest off to one side of the main Ca-rich area. Possibly a carbonate grain?

Leroux [TEM]: Many tiny grains of Ca oxides form by decomposition of probable carbonate in the e beam, so there were carbonates on the sample, but he sees definite contamination by calcite (verified by ED) elsewhere on the section, so maybe all of these are contamination Large grains containing Zr and Al Large and small grains containing Al_2O_3 and SiO_2 (ratio Al/Si typically 1-2/10). Small Ti-oxide (occasionally Fe-oxides) grains. A very large number of small, thin elongated particles (platelets or needles) that appeared rich in Mg and Si (ratio Mg/Si typically within the range 1/5-3/5) or rich in Al and Si.

Track 5

Grain 1

Ishii and Bradley (TEM/Tomo): Tomography of tracks. TEM images of Si-rich glass with embedded metal and sulfides. Analysis of one olivine:Fo_{96}.

Track 10

Bradley [TEM]: 1) Olivine and pyroxene intergrown. Striations in the enstatite crystal are consistent with stacking disorder and unit cell intergrowth of monoclinic clinoenstatite and ortorombic ortoenstatite. No nuclear tracks. 2) LICE forsterite. No nuclear tracks. Glass with metal and sulfides at the grain rims, but these may have been produced during collection.

Joswiak (TEM): Has EDX mineral analyses but most of these require verification: Olivine (Fo_{99-63}), Fe-Ni metal, OPX, Pyrrhotite, Spinel, Al-silicic glass, Ni-Rh metal, SiO_2 glass, Fe-Ni-Cu sulphide, Plagioclase, Na-Ca-Al silicate, Al metal, Calcite, Pentlandite. Zolensky: Comment-Calcite and Al metal are probably contamination.

Mikouchi (FEGSEM): He found both silica-rich amorphous phases and possible Mg-rich silicates in these grains. EDS spectra of Mg-rich silicates usually show high concentration of Si. As is the same case with FC6,0,10,7,15, they are either pyroxenes or olivine contaminated with silica spectra.

Track 13

Grain 1

Butterworth [STXM]: One particle is C rich. One metallic iron particle. Low Ni. Spacecraft?

Stroud [TEM]: Crystalline silicate. The diffraction patterns (three different zones recorded) suggest a monoclinic phase with lattice parameters close to enstatite, but some reflections from enstatite are missing. It could be over coated with some melted aerogel. (Mg+Fe)/Si is 2/3. Same particle was rich in C according to Cody and Alexander.

Rietmeijer (TEM) reports amorphous silicates in the sample, and perovskite on one grid which is not clearly associated with the sample and so could be contamination.

G. Cody and C.Alexander: Particle was rich in C

K. McKeegan (SIMS): Grain 1 has a modest enrichment of D.

Track 16

Grain 1

Only sample preparation picture.

Grain 2

Only sample preparation pictures.

Grain 3

T. Nakamura: Al, Si and Ti, Si rich particles.

T. Mikouchi (FEGSEM): He examined a potted butt which contains two grains exposed on the surface. One of them is a mostly silica-rich amorphous phase possibly contaminated with aerogel. The other grain (2.5 x 1.5 microns) is made of a K-rich phase, probably a K-feldspar. Neither Ca nor Na was detected. It contains only Si, Al and K. I tried EBSD for this grain, but could not obtain diffraction.

Weisberg (SEM EDS): Sees S and Mg by EDS. Possible K-feldspar.

Track 17

Grain 1

Tomeoka [TEM]: Ca-poor and Ca-rich px (high Cr contents). Fe-Ni sulfides, Fe sulfides. Unusual grain (~300 nm) bearing major amounts of Si, O and Mg and minor amounts of Al, Na and K. Low-Ca pyroxene is variable in Fe/Mg ratio, ranging in composition from Fs_2 to Fs_{13} and from Wo_1 to Wo_5. It contains very minor, variable amounts of Al, Cr and Mn. High-Ca pyroxene has a range of composition from Fs_{15} to Fs_{19} and from Wo_{34} to Wo_{40}. Olivine is Fe-rich and also variable in Fa content, ranging from Fa_{30} to Fa_{41}. It contains very minor amounts of Mn. Olivine, has a wide compositional range, but which lacks Mg-rich varieties, unlike the closely associated low-Ca pyroxene.

Simon [TEM]: Their slices consist of numerous grains, though a couple of the slices preserve at least part of the heart shape. Most of the material is anhedral shards, but there are some acicular grains (slice 2), and some nice tabular grains, which tend to have a composition of $En_{95}Wo_1Fs_4$. Heart-shaped pyroxene: It is mostly Mg-rich, low-Ca pyroxene. The Wo component ranges from 0 to 24% and Fe/(Fe + Mg) from 0.035 to 0.48. There is also a small amount of olivine present. I have three analyses so far, all about Fo_{60}.

Track 18

Flynn (SXRF, SXRD): No crystalline materials observed, only Fe and Ca seen in XRF spectra.

Track 19

Flynn (SXRF): Enriched Ni, Fe, Zn along the track

Track 20

Flynn (SXRF): Fe-Ni rich grain present, track is generally chondritic

Track 21

Flynn (SXRF): Two terminal grains present. Both particles are approximately chondritic except that Ni/Fe is very low and Ca is high.

Track 22

Flynn (SXRF): Overall Track composition – generally approximately chondritic, but Ni/Fe a bit low. High K.

Lanzirotti (XRD]: Possible match for forsteritic olivine, though an intense reflection does not match

Westphal (ALS): Ca in the aerogel. XRF spectra were obtained for terminal particles. Generally chondritic, but Ni/Fe varies from low to extremely low compared to CI. The two largest terminal particles, 6.6 and 5, both show sulfur -- suggesting heating did not severely remobilize S in these ~10 to ~20 um particles. The terminal particles are generally Fe_3+ rich. Particles closer to the entry point in Track 22, the longest track and the only one with large particles along the middle of the length, are Fe_2+ rich. A few weak diffraction spots indicate some crystalline material is present in several particles.

Sutton et al. (APS): Both Zn and Ni are much higher in the wall of the entry region than in the terminal particle. We see a bit of S there (not shown in images) as well, and suspect Fe- and Zn- sulfides were deposited along the wall. High Zr spot seen at the end of the track

Joswiak (TEM): Collected a number of EDX analyses of olivine, glass and some other phases from a ~5 um particle lodged in the wall of Track 22. This particle is essentially a large, reversely zoned olivine grain and some Mg+Al silicate glass. Three other minor phases - FeZn sulfide, FeNi sulfide and a likely Cr+Fe+Ti oxide (spinel of some kind?) - all seem to occur as inclusions.

Langenhorst (TEM): Reports TiO_2 among the grain, but TiO_2 appears to be a contaminant.

Track 23

Nothing yet.

Click here to return to the *Stardust Catalog* Table of Contents

Track 24

Keller (FTIR): Pyroxene plus aerogel.

Track 25

Grain 4

Bradley, Ishii, Dai, Miaofang [STEM]: Diopside, Spinel, Glassy silicates with sulfide inclusions, V containing Osbornite, Sulfide on the rim, Anorthite, Gehlenite, possible Sapphirine.
Joswiak (TEM): reports analyses and identifications of many phases, including TiN, anorthite, Ti-Al rich diopside, melilte, spinel. Some identifications require verification. There is discussion back and forth with Steve Simon regarding reduction of diopside (fassaite) analyses.

S. Simon & L. Grossman (E-beam): Their samples were FeO- and alkali-free and completely composed of CMAST oxides, but it is certainly not a typical CAI like we are used to. Its bulk composition is 11.44 wt % MgO; 23.66 Al_2O_3; 48.95 SiO_2; 15.54 CaO; and 0.32 TiO_2. It is SiO_2-rich and CaO-poor compared to normal CAIs. It is not spinel-saturated, but if projected from spinel on the Stolper diagram (gehlenite-forsterite-anorthite ternary) is would plot near the An-Fo join, at about $An_{85}Fo_{15}$, with a negative gehlenite component. The TEM shows that all of the grains in the object look similar to each other, massive and featureless. They are crystalline, and three analysis spots have compositions consistent with aluminous diopside.

There is also a grain that is MgO- and TiO_2-free but does not have quite the right composition/stoichiometry for anorthite. Most (but not all) analysis spots did not have any detectable TiO_2. The thicker grains look dark in the TEM view and are bright in the SEM images.

One crystal of spinel, about one micron across. An analysis of it plots on a mixing line between pure $MgAl_2O_4$ and an analysis of the silicate host on all oxide-oxide plots.

So, the object consists of the same oxides that typical CAIs do, and may have had typical CAI phases originally, but does not have a bulk composition or mineralogy like the CAIs we find in meteorites.

Track 26

Joswiak (TEM): Fayalite, SiO_2, Cubanite (not confirmed).

Track 32

This Track is obviously paired with track 69

Grain 1

Keller (FTIR): Enstatite + maybe glass - silicate feature is saturating the detector. Possible hibonite?

K. Messenger (TEM): Enstatite present.

Grain 2

No Data.

Grain 3

K.Messenger (TEM): Main phase is enstatrite.

Track 35

Grain 1:

Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH

Grain 3:

Tsuchiyama (CT Tomo): Small grains of heavy minerals (kamacite and Fe-Ni sulfides, presumably: the size of some grains must be less than the CT spatial resolution) are embedded in a porous material (aerogel + sample?). Presence of large voids in the porous material shows large-scale vesiculation, such as melting. The porous material has smooth and rough surfaces

Grain 4:

T.Nakamura, Ohsumi and Mikouchi (SXRD): Crystalline, having olivine, both high and low Ca pyroxene (OPX), and plagioclase (probably anorthite). Ohsumi did site occupancy of olivine, and it is Fo_{89}.

Tsuchiyama (Tomo): Crystalline sample. Very small grains of heavy minerals (Fe sulfide or magnetite?: metal is also possible) are present along the grain boundaries of silicates. Portions which seem to be mesostasis are also seen. If this is mesostasis, this sample has prophyritic texture. Small voids are also present. The particle is partially covered with a porous material (aerogel + sample?). Fractured surface without covering the porous material is also seen.

Grain 5:

T. Nakamura (SXRD): chondritic composition, sulfide and kamacite are only crystalline phases, suggesting that silicates are amorphous.

Tsuchiyama (Tomo.): grain has vesicular texture.

Grain 6:

T. Nakamura (SXRD): Olivine, low-Ca pyroxene.

Tsuchiyama (CT Tomo.): This particle shows micro-porphyritic texture. If the phenocrysts are olivine, the Mg# estimated from the CT values (linear attenuation coefficients in the CT images) is approximately 0.8. This needs verification. Relatively large kamacite grains are also seen (mode: ~1 vol.%). Small voids are also present. The particle is partially covered with a porous material (aerogel + sample?). The particle surface is rounded and any fractured features are not seen

Grain 16:

Keller (FTIR): Mostly melted aerogel.

Tsuchiyama (Tomo.): Microporphyritic texture, with feromags and kamacite.

T. Nakamura (SXRD): Crystalline olivine, low-Ca pyroxene, kamacite.

Aleon et al (SIMS: No presolar grains.

Velbel &Harvey (TEM/SEM): Provide many Fe-Ni sulfide analyses. All Fe-Ni sulfides are S-depleted. Give bulk analyses of Si mixed with chondritic material, and suggest that these are not merely GEMS. Provide many SEM images of same. Observe pyrrhotite, troilite, kamacite by ED, possibly also graphite and an Fe carbide by EDX-ED.

T. Stephan (TOF-SIMS): Measured trace elements, most elements chondritic, Ba, Cu, K, Na, Al, Rb, Sr, 10-100 x CI.

K. Tomeoka (TEM): microcrystalline material includes closely-located grains if kamacite, troilite and pyrrhotite (all verified by ED), within the amorphous glass.

Grain 17:
Keller (FTIR): aerogel + melt + weak CH (IDP like)

Grain 18:
Keller (FTIR): Melted aerogel

Grain 19:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH

Grain 20:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH

Grain 21:
Keller (FTIR): Aerogel with strong CH band by FTIR
Meibom (SIMS): Stable Isotopes reported
Borg (Raman): Organics investigated

Grain 22:
Keller (FTIR): Aerogel with strong CH band by FTIR

Grain 23:
Keller (FTIR): Aerogel plus strong CH

Grain 24:
Bridges (TEM): EDX spectra reveal dominant aerogel, with 2 types of cometary material: Mg-Fe-(Ca)-silicate; Fe-sulphide. Some of the EDS spectra are mixtures of these 2 types, One spectrum contained Ca in addition to the Mg-Fe-(silicate).

Keller (FTIR): All analyses + Si-O (aerogel presence).

T. Stephan (SIMS): Mg, Ca, Ti, V, Fe, Mn, Co, Ni are chondritic; Na, Al, K, Cr, Cu, Rb, Sr, Ba 10-100 x CI.

Rietmeijer (TEM): Finds the amorphous Si-bearing material to be un-GEMS like. He sees another Si-rich glassy material which has Mg, Fe, S, etc, that appear more GEMS like. He reports Fe-Ni sulfide compositions, including some that are *enriched in S*, and some that have very high Ni, and cannot have originated from partial volatilization of troilite. He sees both kamacite and taenite (by ED). He sees brookite grains which appear to be in the epoxy only and are probably contamination (?).

Grain 25:
Keller (FTIR): Aerogel plus minor melt.

Grain 26:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH

Borg (Raman): Organics investigated

Meibom (SIMS): Stable isotopes.

Grain 27:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH
Meibom (SIMS): Stable isotopes.

Grain 28:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH

Meibom (SIMS): Stable isotopes.

Grain 29:
Keller (FTIR): Mostly melt

Meibom (SIMS): Stable isotopes.

Grain 30:
Keller (FTIR): Organic-rich plus melt (?)

Meibom (SIMS): anomalous ^{13}C and ^{15}N.

Grain 31:
Keller (FTIR): aerogel plus melt

Grain 32:
Keller (FTIR): aerogel + distinct melt above 10 um, weak CH

Bridges (TEM): The sample is dominated by aerogel with MgFe-silicate. S contamination reflecting the mounting medium is present. All analyses + Si-O (aerogel presence).

Langenhorst (TEM): Reports TiO2 and FeS among the grain, but TiO^2 appears to be a contaminant.

Grain 33:
Keller (FTIR): melt plus aerogel

Grain 34:
Keller (FTIR): aerogel only

Grain 35:
Keller (FTIR): aerogel plus melt

Grain 36:
Keller (FTIR): aerogel only

Grain 37:
Keller (FTIR): aerogel plus melt

Grain 38:
Keller (FTIR): aerogel plus melt

Grain 39:
Keller (FTIR): aerogel plus melt plus contaminant

Grain 40:
Keller (FTIR): aerogel plus melt plus contaminant

Grain 41:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH
16

Grain 42:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH

Zega (TEM): Nanocrystalline Fe-Ni sulfides embedded within amorphous material is the major component. Sulfides contain minor Cr and P. Amorphous material is composed of O, Mg, Al, Si, and Ca. One slice contains graphitic C (is this contamination?) and noncrystalline Cu (contaminant from grid?).

Bajt: Organics

Grain 43:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH

Grain 44:
Stephan (TOF-SIMS): Chondritic Li, Na, Mg, Ca, Ti, V, Cr, Mn, Fe, Co, Ni; while Al, K, Sc, Cu, Sr, Rb, Ba 10-100 x CI.

Grain 45:
Keller (FTIR): aerogel plus strong CH

Zega (TEM): Nanocrystalline Fe-Ni sulfides embedded within amorphous material is the major component. Sulfides contain minor Cr and P. Amorphous material is composed of O, Mg, Al, Si, and Ca.

Stephan (TOF-SIMS): Only Li, Na, Fe, Ni are chondritic.

T. Nakamura (SXRD): No crystalline silicates, only amorphous materials and metal

Grain 46:
Keller (FTIR): olivine plus melt plus aerogel

T. Nakamura (SXRD): No crystalline silicates, only amorphous materials and metal

Grain 47:
Keller (FTIR): aerogel + distinct melt above 10 um, v weak CH

T. Nakamura (SXRD): No crystalline silicates, only amorphous materials and metal

Grain 48:
Keller (FTIR): aerogel+minor melt + weak C

Grain 49:
Keller (FTIR): pyx+oliv+melt+aerogel

T. Nakamura (SXRD): crystalline olivine and low-Ca pyroxene

Grain 50:
Keller (FTIR): aerogel+minor melt + weak CH

Grain 51:
Keller (FTIR): aerogel+minor melt + weak CH

Grain 52:
Keller (FTIR): aerogel+minor melt + weak CH

Mikouchi (SEM/TEM): Mainly composed of amorphous silica with scattered small particles of Fe, Ni metal or Fe sulfide. Some areas show the enrichment of Mg, suggesting that they are Mg-rich silicates. No Fe was detected for these Mg-rich silicate phases.

Bajt: Organics investigated.

Grain 53:
Keller (FTIR): aerogel+minor melt + weak CH.
Bajt: Organics investigated.

Track 36
Leroux (TEM): Contains pyrrhotite. Diffraction data are consistent with two a hexagonal structure (slightly distorted): a = 5.88, c = 11.39 Å, but the strong diffraction spots can also be described by a monoclinic structure: a' = 11.902, b' = 6.86, c'= 22.787 Å, β = 90.43.

Wirick (STXM): organics correlate with fractures (chatter?) in sulfide crystal; is this evidence of organic contamination during microtomy?

Track 37
No Data.

Track 38
Brennan et al: Track was mapped.

Markus et al (various): Present in two terminal grains Fe, Ni metal, FCC structure consistent with taenite. Confirm SSRL discovery of a Ga-rich, Ni-poor unknown crystal (crystalline) halfway down the track – they provide one ED pattern.

Track 39
Brennan et al: Track was mapped only.

Track 40
Ishii: et.al: Track was imaged only.

Track 41
Markus et al. (various): Dozens of particles. They appear to be much more homogenous (e.g., Ni/Fe, Zn/Fe, FeXANES) than the particles in the smaller tracks. XANES shows Fe is Fe0. Implies a dependence of homogeneity on particle size.

Track 42
Markus et al. (various): Three sulfide particles, including sphalerite and pyrrhotite reported, requires verification.

Track 43
Markus et al. (various): Multiple particles and a large terminal particle analyzed. One olivine, 3 mixed pyrrhotite+oxide(?). Terminal particle is contains Fe-Ni metal

Track 44

Grain 1

T.Nakamura (SXRD): Seussite (Fe_3Si), probably formed during capture.

Grain 2

T.Nakamura (SXRD): Seussite (Fe_3Si), probably formed during capture.

Grain 3

Tsuchiyama (CT tomo.): Small grains of heavy minerals (kamacite?: the size must be less than the CT spatial resolution) are embedded in a porous material, which may be aerogel with or without very fine cometary dust samples. Presence of large voids in the porous material shows large-scale vesiculation, such as melting

Grain 4

Rietmeijer (TEM): Particle contains extremely rare pyrrhotite, extremely rare grains that are a regular mixture (crystallographic controlled intergrowth?) of pyrrhotite and kamacite, round kamacite inclusions in the aerogel, $(Fe,Ni,Cr)_3Si$ spheres (seussite) scattered in aerogel, and single crystal forsterite. He provides many analyses of sulfides, olivine, seussite, Fe-Ni metal and Si-rich glass. He is confident that the Fe-silicide (seussite) spheres are the reaction product between iron from comet material and aerogel. If so, the Fe-Si phase diagram would suggest peak-heating temperatures at least on the order of 1200-1400 ^{o}C. The amorphous zone betwen forsterite and aerogel does not represent an "inert compressed aerogel". It suggests chemical exchange between the comet dust and the aerogel capture medium. The process is unclear: it could be a melt zone or due to solid-state diffusion at very high chemical diffusion rates.

T. Stephan (Tof-SIMS): Most analyzed elements have essentially chondritic abundances; but K Co, Cu enriched up to 5 x CI.

Tomeoka (TEM): Fe-Ni metal (incl. kamacite) within Si-rich amorphous material.

Grain 5

Leroux (TEM): The sample consists mostly of an amorphous silica-rich matrix with numerous small metal droplets. This matrix contains also low and variable amount of Mg, Al, Ca. It is a mixing between melted aerogel and a melted cometary grain. The metal droplets are crystalline. Sulfur is found associated with metal but is found mainly within the silicate. The sample is probably a quenched impact melt, with evidence for silicate-metal immiscibility. Some sulfide crystalline grains are present. They seem to be nonstoichiometric with an excess of S. Diffraction compatible with pyrrhotite (monoclinic C2/c). Other are metallic Si and metallic Al, which are probably contaminants. He gives analyses of Fe-Ni-S droplets, *the ones that are near stoichiometric have Ni far below 1%.* He finds close to chondritic composition by EDX scans. Contaminants *out of the slices* are TiO_2, CaO and Ca Carbonate.

Stephan (TOF-SIMS): This particle is really chondritic. There are only minor deviations from CI. B, C, O, Si comes from the aerogel and Cl is in the epoxy. Al has a hot spot at one edge of the sample. Here besides aerogel only Al is present. I omitted this 1 µm spot for the calculation of the composition since it is probably some kind of contamination. The rest of the particle has CI-like Al. I also provided some RBG-three color images. They show three elements in one picture. It is obvious that Ca is present in a layer surrounding the particle. This all lies within the outline defined by Si that mainly comes from aerogel.

T.Nakamura (TEM): Both particles are 5~10 microns in size and contain only Fe metal as major crystalline phases. However, the d-values of the phase are smaller than the pure Fe metal, indicating some smaller element is present with Fe. I suggest that Si is present with Fe, forming suessute Fe_3Si. This mineral completely matches all observed reflections.

Rietmeijer (TEM): Extremely rare pyrrhotite. Extremely rare grains that are a regular mixture (crystallographic controlled intergrowth?) of pyrrhotite and kamacite, round kamacite inclusions in the aerogel, $(Fe,Ni,Cr)_3Si$ spheres scattered in aerogel, and single crystal forsterite.

K. Tomeoka (TEM): microcrystalline material includes closely-located grains if kamacite (verified by ED), within the amorphous Si glass.

Track 45

No Data.
19

Track 46

No Data.

Track 47

T. Nakamura (SXRF): Bulk composition reported.

Track 48

No Data.

Track 49

No Data.

Track 52

Markus et al. (various): One Cr-rich terminal particle, analysis pending.

Track 55

No Data.

Track 56

Joswiak (TEM): Roedderite-eifelite (confirmed), OPX, Richterite (unconfirmed), Chromite (unconfirmed), SiO_2 glass.

Track 57

Joswiak (TEM): Many fine particles of olivine, FeS and more. Grid with forsterite sent to S Messenger for nanosims. Olivine Fo99.5, trace Cr.

Stephan (TOFSIMS): Three grains analyzed, and none have chondritic compositions.

Track 58

Borg/Simionivici (SXRF): Composition on whole track.

Track 59

Borg/Simionivici (SXRF, XANES, XRD): Composition on whole track. Pyrrhotite and pentlandite in terminal grain verified by Rietveld analysis. They report that sulfates are present at the track entry hole (micro-XANES), and that the oxidation state of S decreases down the track.

Bajt (STXM): Organics mapped.

Track 60

Borg/Simionivici (SXRF): Composition on whole track.

Track 61

Borg/Simionivici (SXRF): Composition on whole track.

Track 62

Borg/Simionivici (SXRF): Composition on whole track.

Track 63

No Data.

Track 65

No Data.

Track 66

No Data.

Track 67

T. Nakamura (SXRF): Bulk composition reported.

Track 68

T. Nakamura (SXRF): Bulk composition reported.

Track 69

This Track is obviously paired with track 32

Grain 1

T. Mikouchi (FEGSEM, EBSD): Mainly Low-Ca pyroxene, with minor olivine, high-Ca pyroxene and Fe sulfide. He reports some olivine and pyroxene analyses. Electron diffraction analysis suggests that their grain sizes are mostly small (<<1 micron). It is noted that many Mg-rich silicate grains contain significant amounts of Fe. Later FEG-SEM analysis also showed that they are mainly composed of Mg-rich silicates with high Fe abundance. One grain of high-Ca pyroxene was detected and EBSD analysis confirmed its crystal structure as diopside.

Grain 2

Zolensky (E-Beam): Low-Ca pyroxene is main phase in grain.

Grain 5

T. Mikouchi (FEGSEM): The sample size is about 15 x 5 microns. It is almost all composed of amorphous silica. No Mg-rich area was found on the surface. One area contains 50-100 nm particles of Zr-rich oxide phase.

Grain 6

T. Mikouchi (FEGSEM): The sample size is about 10 x 10 microns. It is completely composed of amorphous silica. No Mg-rich area was found on the surface.

Track 70

No Data.

Track 71

No Data

Track 72

No Data.

Track 73

No Data.

Track 75

T. Nakamura (SXRF): Bulk composition reported.

Click here to return to the *Stardust Catalog* Table of Contents